RICE DRYING IN SOUTH VIETNAM

August 1968

Dear Sir:

Vietnam faces a grain drying and storage problem common to many developing nations with extensive plantings of new high-yielding, early maturing varieties. Sharp increases in yields, with some wet season harvests, bring into sharp focus the need for new grain drying methods.

The attached study analyzes the drying problem associated with Vietnam's accelerated rice production program. It recommends solutions. Much of the analysis and many of the recommendations contained in this report are relevant to other nations where high yielding rices are being introduced.

Sincerely,

Lester R. Brown

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Administrator

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RICE DRYING IN SOUTH VIETNAM

by R. A. Saul, N. C. Ives, and W. V. Hukill
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USAID/Saigon requested a team of men experienced in grain harvesting and drying who would make recommendations for handling the immediate problem of storing and drying the increased production of rice in Vietnam. This report is in response to that request.

Our briefing in Washington by International Agricultural Development Service and U. S. Agency for International Development people indicated the problems in Vietnam to be:

1. New rice varieties, effectively responsive to fertilizer, can increase yield two to four fold.

2. These new varieties are not photoperiod sensitive, which will promote more than one crop of rice from the same field.

3. This combination will result in considerable harvest during the rainy season.

4. Based on estimates of present rainy season harvest, losses due to spoilage, insects, etc. can run as high as 50%.

5. If high losses due to rainy season harvest result in heavy losses because of inadequate drying facilities, farmers could refuse to continue in the increased rice production program.

Continued briefing in the Philippines indicated the following:

1. The people at International Rice Research Institute (IRRI) were most concerned that mechanical drying with high temperature air be properly used to prevent checking of the rice kernel with subsequent breakage in milling.

2. The new varieties such as IR-8 should be harvested while containing 26% moisture to prevent excessive field losses due to shattering.

3. Most of the planning and engineering effort was directed toward bulk handling of rice.

4. There were about 30 heated air bulk or continuous flow driers in the Philippines which were not in use because of improper location and/or lack of bulk handling facilities.

5. There is an educational program underway to improve sun-drying methods and facilities including the introduction of plastic ground sheets.

Comparing conditions in Vietnam with those in the Philippines, the following observations were made:

1. We observed no mechanical driers in Vietnam at present.

2. There appears to be no place in which large capacity driers could be located to advantage at the present time in Vietnam. There is no institution such as the Rice and Corn Administration (RCA) in Vietnam, and no private rice miller we visited indicated he was really aware of a high moisture rice problem. In general, they seemed satisfied their drying patios were adequate.

3. There is no in-country source of driers or drier components such as fans or blowers in Vietnam.

4. In An Giang Province, a definite program is underway to provide covered drying floors which will be above flood water level for drying during the rainy season.

Mr. William Janssen, ADDP/RP Grain Handling and Storage Advisor, took us on an extensive tour of Saigon rice mills and storage warehouses and of most of Region IV where security made travel possible. We talked with mill owners, farmers, regional and provincial agricultural advisors and their Vietnamese associates.

Mr. Moses J. Morgan, ADDP/RP Farm Machinery Engineer, advised us on the availability of mechanical and construction components in Vietnam.

Design Conditions for Rice Driers

Briefing, interviews, observations, literature and data have convinced us that any suitable drying and storage program for taking care of increased rice production in the Mekong Delta and most of the rice producing areas in South Vietnam during the rainy season must perform under the following conditions:

1. Average relative humidity 85%, average temperature 80 degrees;

2. Rice harvested at a moisture of 26%;

3. Harvest in a given area to be completed within a period of not over three weeks;

4. Most farms producing not over 1 to 2 hectares of rice;

5. Comingling rice immediately following harvest not tolerable by farmers;

6. Burners for oil, gas, or other fuel not acceptable for operation by small farmers generally; and

7. No system depending on electric power to be generally suitable at farms.

The above conditions are understood to exist now. If at some future time any of them can be modified, then other types of drying might be more appropriate than the one we recommend.

Considering how the success of increased wet harvest production might depend on storage and drying facilities, it appeared to us that present farm-type storage facilities were fairly adequate, even though it would be desirable to improve them, and that farmers are capable of providing for themselves any additional storage space on the farm as needed. The one critical requirement is that the rice be dry when put in storage.

On the other hand, prompt drying after harvest during the wet season cannot be accomplished by merely expanding present drying facilities. Unless new methods of drying are available to farmers, much or all the prospective increase in production will spoil before it can be used. For this reason, our attention has been confined largely to considering what methods of drying can be used under the circumstances. Many kinds of grain dryers are used in various parts of the world. These can be grouped as follows:

1. <u>Patio drying in the sun</u> - The grain is spread in thin layers on the ground or specially prepared areas and sunshine dries the grain if it is raked frequently and if it is covered during rain storms. With sufficient personal attention and labor, this is successful if the moisture content is not too high and if the climate is dry enough. This is a common practice in Vietnam and would be adequate for any projected increase in production during the dry season, assuming only that larger ground areas could be assigned to it and that additional man hours are available. It is our opinion that rice harvested during the wet season could not be salvaged by this method without space and labor requirements that would be excessive and unrealistic even granting the willingness of the farmer and his family to devote all their available time to drying. In patio drying, the exposure to the sun results in kernel breakage which in itself does not affect the effectiveness of drying but reduces the value of the dried rice. This method offers little promise of meeting the problem.

2. Sack drier - Sacks of rice are laid over holes in a platform in such a way that air can be blown up through the rice in the sack. With one sack over each hole, the platform can be made large enough to accommodate any desired number of sacks at a time. The rice being in sacks, any number of farmers could use one such facility because the sacks would permit retaining the identity of ownership. In the rainy season, the air blown through the sacks will have to be heated. The low resistance to air flow through the sacks makes it impractical to use the heat from an engine for raising the temperature of the air. The necessary heat would have to be supplied by a burner of some kind - oil, gas, rice hulls, charcoal, etc. It is our opinion that the problems of burner control, maintenance, parts supply, safety and unfamiliarity with equipment for heating moving air would make this method unacceptable under the present circumstances. However, in the future, it may become acceptable.

3. Flat bed drier - Bulk rice is put on a platform with holes in it that permit air to flow upward through it, but will not let rice through. The area of the platform can be made large enough to accommodate any desired quantity of rice. The air must be heated to accomplish the necessary drying. More will be said about this type of drier since it appears to be more adaptable to the present situation than any other type.

4. Deep bed drier with layer drying - A storage bin is equipped with a floor with holes in it. A layer of bulk rice is put on the floor and slightly heated air is blown through it. As that layer dries, a second layer is put on top. Drying proceeds as successive layers are added. When the bin is full, the dried rice can be left in the bin for storage if desired. Since this method involves comingling of all the rice in the bin, it can be used only when the quantity of rice in one lot justifies the cost and use of the facility. More will be said about this method as it might apply to the larger producers.

5. Conventional portable heated air driers - Rice is put in the drying compartment of a drier which can be moved from place to place. Heated air is blown through the rice which is dried either continuously or in batches. Under present circumstances, this drier does not seem practical.

6. Stationary commercial grain driers - Rice is sometimes dried at central receiving points, usually adjacent to a mill. It is dried as received and is usually in transit in the marketing system, the farmer no longer having title to it. Such driers can exercise quality control and operate economically if their design and management are adequate. They are compatible with certain patterns of

marketing and grain movement, but do not offer much possibility for answering the present problem. The production, handling and marketing system may eventually develop in such a way that this type of drier will have a substantial part in keeping the rice in condition. But that is for the future.

7. Vacuum driers, infra-red driers, chemical absorbent driers, heat pump driers, etc. have been proposed and some have been used in special application but we have not seen how these methods can be applied toward solution of the present problem.

Proposed Flat Bed Drier

From the known types of drying systems, we have concluded that the flat bed drier offers more promise of practical operation for the conditions outlined in the previous section. It is proposed that a limited number of such driers be constructed and operated as soon as possible. Each drier will serve a number of farmers who will bring their rice to the drier and take it away after drying. It should be located at a point where it may have the best chance of successful operation. The first driers built will serve as pilot driers where the many management problems can be observed and overcome. They will serve as demonstration units and used as models for whatever number of driers are required as wet harvest production increases in volume. It is anticipated that construction and operation of these units will disclose problems that can only be solved by adapting the construction and management to local conditions. For example, concrete may be appropriate in one locality and steel in another.

This application of the flat bed drier takes advantage of the general availability of gasoline or diesel engines and the familiarity of farmers with their operation. The heat for this drier is supplied by the fuel burned in the engine. Air is blown through the rice by a fan. Heat from the motor driving the fan increases the temperature of the air enough for drying. In order to operate successfully, the quantity of rice, the quantity of air supplied, the air pressure provided by the fan, the temperature rise of the air, and the size of the engine must all be accommodated to each other.

Figure 1 on page i of the Appendix is a sketch of the proposed drier showing the essential dimensions. The figure shows dimensions for four sizes. It is essential that the dimensions shown for a given size of drier be adhered to. Other dimensions are optional. The

capacity and essential dimensions and horsepower are listed as follows for four sizes:

Rated Engine Horse-power	Floor Area of Bin (Sq. Ft.)	Depth of Air Chamber (Inches)	Depth of Rice (Inches)	Metric tons of Rice	Blower Delivery	Blower Pressure	Minimum Area of Entry to Air Chamber (Sq. Ft.)
3	40	12	42	2.2	1,500 cfm	3.0	1.5
6	80	12	42	4.4	3,000 cfm	3.0	3.0
12	160	12	42	8.8	6,000 cfm	3.0	6.0
24	320	12	42	17.6	12,000 cfm	3.0	12.0

Each element of the drier has certain rigid requirements which can be met in a number of ways. The elements are as follows:

1. The rice holding compartments - These must be 42" deep and have a total floor area as shown in Figure 1. For the 3 HP unit, this is 40 sq. ft. The walls of the compartments can be of any material such as wood, concrete, or steel. They must be strong enough to hold the rice in place and must not permit the loss of air through the wall.

2. The perforated floor - It must permit the air to move upward into the rice without letting the rice fall through the openings. A lattice of steel, wood, or other material with fly screen on top of it will serve. Perforated sheet metal is frequently used in places where it is available. The false floor must be supported adequately, either by piers or, if the floor material is stiff enough, by resting on the side walls. The floor surface should not be so rough that the rice cannot be swept or scooped up after drying.

3. Partitions - To permit several farmers to use the drier at the same time, vertical partitions will be installed, making compartments of such size that each farmer puts his rice in one or more compartments, unmixed with other rice. Three compartments are shown in Figure 1; but, the number and spacing of partitions will have to depend on the number of farmers and the quantity of rice each will be drying. It may be anticipated that it will be necessary to operate the drier at times when some compartments are empty. In this case, the air flow through the empty compartment must be blocked off. This can be done by covering the vacant floor with a panel of steel, plywood, or perhaps heavy paper mounted on a frame which must be

held down against the pressure of the air, or a sliding door under each bin can be provided to cut off air supply during emptying and filling of any one bin.

4. <u>Air chamber</u> - The space below the false floor must be air tight and at least one foot deep.

5. <u>Entry to air chamber</u> - An opening in one wall of the air chamber will permit connection to the fan discharged by a transition piece. The area of this opening must be at least as large as the area shown in Figure 1 under "minimum area of entry to air chamber." It may be as much larger as is desired.

6. <u>Fan air chamber transition duct</u> - This is preferably made of sheet metal; but, may be of other available material. It is a short duct connecting the fan discharge with the air chamber. If the area of the fan discharge is less than the areas shown in Figure 1 under "minimum area of entry to air chamber," it will be necessary to use a tapered duct. The transition piece needs to be long enough so that angle of divergence of any side does not exceed 7 degrees.

7. <u>Blower</u> - The air volume to be supplied by the blower is shown in Figure 1. The pressure against which it operates is 3". The selection of the blower is perhaps the most critical of all the requirements of the drier. For the smallest drier shown in Figure 1, it is necessary to use a blower which is rated by the manufacturer to deliver 1,500 cfm against a pressure of 3". The rating will also show how fast the fan must run to give this flow. The pulley and belt system to drive the blower must be such that the blower will operate at the RPM specified by the manufacturer, when driven by the engine at its normal load RPM.

8. <u>Engine</u> - The combination of requirements shown in Figure 1 has been computed on the basis of using a gasoline engine of a rated horsepower as given in the Figure. For this reason, it is desirable that gasoline engines be used with the first units installed at least, but the operation should be nearly as satisfactory if a diesel of the same horsepower rating has to be substituted.

9. <u>Housing for blower and engine</u> - This is merely an enclosure of any air tight material that insures that all the air that moves past the engine goes into the blower. This is a necessary part of the layout because the heat from the motor is depended upon for drying.

10. <u>Engine exhaust</u> - We do not know whether the exhaust from the engines when discharged into the drying air, will have an objectionable effect on the rice quality. If it does, the exhaust air can be conducted out of the housing with a short hose or pipe. This will result in reducing the drying effect.

11. Roof over bin - A rain-proof roof is necessary over the rice bin. It may be of any material that prevents rain from falling on the rice. It need not be connected directly to the bin.

12. Orientation of bin - In order that the moist air coming out of the rice does not move to the engine and join the drying air, it is desirable that the engine and fan be mounted so that the prevailing wind during the wet season blows from the motor toward the bin.

It may be anticipated that a number of problems will be encountered in the construction and operation of the flat bed driers described. These will have to be met as they come up. Such problems are likely to include:

1. Grain shrinkage - The bin will be full when it is loaded. After drying, it will have shrunk and the farmer will have to understand that he has not lost any rice.

2. Level filling - All compartments having rice in them should be full. Do not permit operation with partly filled compartments.

3. Empty compartments - The air will have to be blocked off from any compartments that are not filled with rice. Some kind of air block will have to be devised.

4. Fan operation during filling - It may not be practical to fill bins while air is coming up out of the compartment. Either the blower will have to be stopped during filling or a sliding closure will have to be provided. It may be necessary to limit loading and unloading to a specified one or two-hour period, say 8 to 10 in the morning. Do not schedule this shutdown during the middle of the day because the best drying times would then be missed.

5. During the wet season, a farmer will have to accumulate two days of harvested rice. It may be advisable to have a few rice containers at the drier site to take care of this accumulation. In many cases, this can be taken care of by the farmer himself.

6. Presumably, security against theft will be necessary at the drier site. It may be advisable to have the drier adjacent to living quaters of the person in charge.

This type of drier has some advantages not previously mentioned. Less kernel breakage will occur in rice dried this way than if high temperatures were used or if the rice were exposed to the sun.

This suggests another possibility. To prevent field losses due to shattering, it is recommended that IR-8 be harvested at about 26% moisture. Sun drying of rice at this moisture will cause excessive kernel checking with subsequent breakage during milling. The flat bed drier should be used for dry season harvest which would do two things. First, it would result in the highest quality rice with lowest field losses. Second, it would spread the initial cost of the drier over more tons of rice.

Cost of equipment - Actual in-place cost is difficult to estimate. Assuming that substantial numbers of the units will eventually be erected, the construction costs for labor and materials as well as costs of blower and engines and the fuel costs for two days of operation might, according to our present information, be about as follows:

Construction and Operating Costs

Unit	Construction	Blower and Engine	Total 1st Cost	Fuel Cost Two Days	Supervision Labor 2 Days	Total Operating Cost 2 Days
3HP	$ 160	$110	$ 270	$ 3.25	$6.00	$ 9.25
6HP	300	175	475	6.50	6.00	12.50
12HP	550	310	860	13.00	6.00	19.00
24HP	1,100	600	1,600	26.00	6.00	32.00

The above estimates, particularly for construction, are highly speculative. They are subject to revision after pilot plants are erected. For the present, they may be a satisfactory basis for predicting the cost of saving the wet harvest season rice. It is assumed that the drier will operate for 21 days during the wet season, and that in 21 days, at least eight batches will be dried, each batch being in the drier for two days.

Proposed Storage Bin Drier

The deep bed drier listed as number 4 above may be more practical in certain respects than the flat bed drier for the larger farmers. It was reported in one province in III Corps that 65 farmers had planted enough rice that each will harvest at least 30 tons in the wet season. We suggest an alternative drying system for the larger farmers, which provides both drying and storage for their anticipated increased production.

1. Equipment - This system requires that a raised, perforated floor be installed in a storage bin and that a fan-engine unit be

attached to the air chamber provided by the raised floor. This system is illustrated in Figure 2, page ii, in Appendix. The capacity of the bin is determined by the size of crop to be harvested or the amount of grain to be dried and stored. The proper proportions of the bin, depth/diameter ratio, may be established by a maximum depth to which the farmer is willing or conveniently able to load the bin by hand methods. Such a maximum depth or height might be about 6 feet or 2 meters. Mechanical filling equipment is probably necessary for greater depths.

2. Operation - The first day's harvest of wet rice is placed immediately into the bin. As soon as the perforated floor is covered with about one foot of rice, the motor and fan are started. Each successive day's harvest is placed on top of the previous day's charge until the crop is harvested or the bin filled. During this harvesting period, the heat and air from the motor and fan which run continuously (24 hours per day) slowly moves the drying zones, which forms in such slow drying systems, up through the wet grain. Typical daily progress of the drying zone is shown by the right hand column of figures in the schematic bin diagram. For example, as illustrated in Figure 2, at the end of the fourth days' filling, the drying front (the top surface or front of the advancing drying zone) will have traversed through all of the previous days' fills. The fan and motor in this example will need to be operated only about two days after placement of the sixth or last day's harvest of wet rice. The fan and motor should never be stopped, except for refueling or trouble, of course, until the top or surface layer of grain is observed to be dry. Drying of the top layer of rice in the bin is evidence that all the rice in the bin below this layer has dried. The nature of the drying process is such that the wettest grain in the bin will nearly always be that near the surface. When this surface layer becomes dry, all the grain below may be expected to be as dry or drier.

About all that is required for intelligent operation or good management of this drying system is a daily observance and record of the advance of the drying zone and a knowledge of the maximum number of days that the wet grain can be allowed to be in the bin above the drying zone. A simple way to locate the drying zone in such a bin is to use a small diameter stick or rod as a bin probe. Pushing this probe through the wet rice, it will, upon passage through the drying zone into the dry rice, suddenly push easier and move faster. A record of these daily determinations will give the daily advance of the drying zone. The depth to which the wet rice is piled above the drying zone should not exceed

at any time a distance greater than that which the drying zone will traverse in the maximum wet rice storage time which, for 26% paddy rice at 80 degrees F, is around four to six days.

3. Design - The results of two calculated designs are presented in Figure 2. The 14 ft. bin holds 15 tons which would serve a 2½ hectare farmer with a 6 ton yield. It provides for a six consecutive days harvest period. An 18" diameter, 3 brake-horsepower vane-axial semi-pressure crop drying fan at 3450 RPM was selected. This would require a 6 to 8 rated horsepower gasoline engine. The drying front is estimated to advance at a rate nearly equal to the selected one foot per day filling rate of the bin. The initial moisture content of the rice was assumed to be 26% wet basis, and the average atmospheric air conditions assumed were 80 degrees F. and 85%. All the heat from the engine was considered to enter into the drying air which results in drying of the rice to about 12%.

   Obviously, a somewhat smaller fan-engine unit could be employed and still move the drying zone through the last layers of wet grain within four to six days after placement. However, until good field performance, experience and confidence by several users is obtained, it is recommended that the fan-engine unit be capable of moving the drying zone through the rice about as fast as the bin is filled.

   The 19 ft. bin shown in Figure 3 provides for a 4.5 ton per day filling rate with a total drying and storage capacity of 72 tons. A backward curved blade centrifugal fan requiring about 5 brake horsepower (a 10 HP gasoline engine) at 2400 RPM was selected. The same atmospheric air and rice conditions as given above were assumed.

   The estimated daily drying front advance for a one foot per day filling rate is shown in the right hand column of figures on the bin diagram. Inspection of this diagram shows that the last three daily charges of rice would be expected to remain undried in the bin for a maximum of six days. If this is determined to be too long a period, one or more alternatives may be taken. A larger fan-engine unit or just a larger engine and increased fan RPM could be provided; or filling could be stopped for one day, say after the 6th and 12th fills, which would reduce the maximum undried time to four days; or filling could be limited to any depth less than 16'.

4. <u>Estimated costs</u> - The costs usually attributed to an in-storage drying system provide for:

   a. the perforated, raised floor

   b. the fan-engine unit including mountings, drives and enclosure

   c. the operating costs of fuel, oil, repairs and that labor required to take care of the unit.

   A rough estimate of these three cost items for the two bins used in the above examples are:

	15-ton bin	72-ton bin
a. Perforated floor	$ 77	$142
b. Fan, engine & enclosure	200	300
c. Gas, oil, etc. per bin of grain	54	210
Total drying cost per ton (assuming annual use cost to be 15%)	6.20	3.80

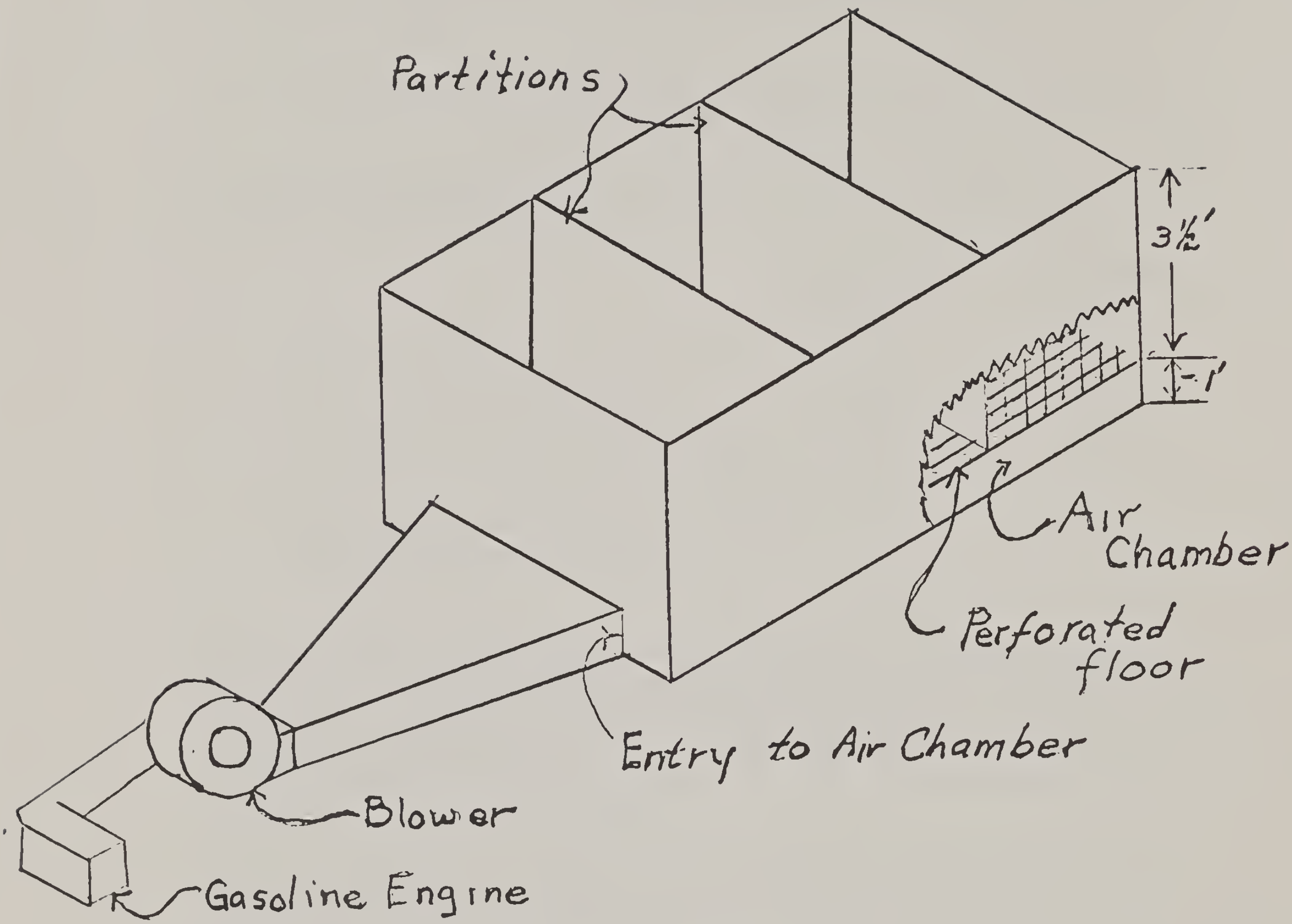
   Where a new or additional storage bin is required, its cost may be included to determine a total drying-storage investment required. Suitable small rural storage bins for 15 tons or less can be built locally out of a variety of materials such as reinforced bamboo matting, plywood or similar wall boards with relatively little cash outlay.

   Larger bins will require the use of sheet steel or reinforced masonry, the costs of which can be expected to vary greatly according to local conditions.

   A projected cost for the purchase and importation of standard steel storage bins may be estimated to vary, according to the size of bin and source of supply, from 50 cents to $1.00 per bushel, or $25 to $50 per ton of paddy rice. Amortizing this storage cost at 10% per year gives an annual cost of $2.50 to $5.00 per ton. Adding the above estimated storage and drying costs in the various combinations possible gives a maximum range of $6.30 to $11.20 per ton as a rough projected costs figure for a complete drying-storage system for one crop per year.

- A P P E N D I X -

Figure I Flat Bed Drier



Heat housing over engine and blower not shown.

Rated Engine Horse-power	Floor Area of Bin (Sq. Ft.)	Depth of Air Chamber (Inches)	Depth of Rice (Inches)	Metric tons of Rice	Blower Delivery	Blower Pressure	Minimum Area of Entry to Air Chamber (Sq. Ft.)
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Fig. 2 In-Storage Progressive Filling-Drying System

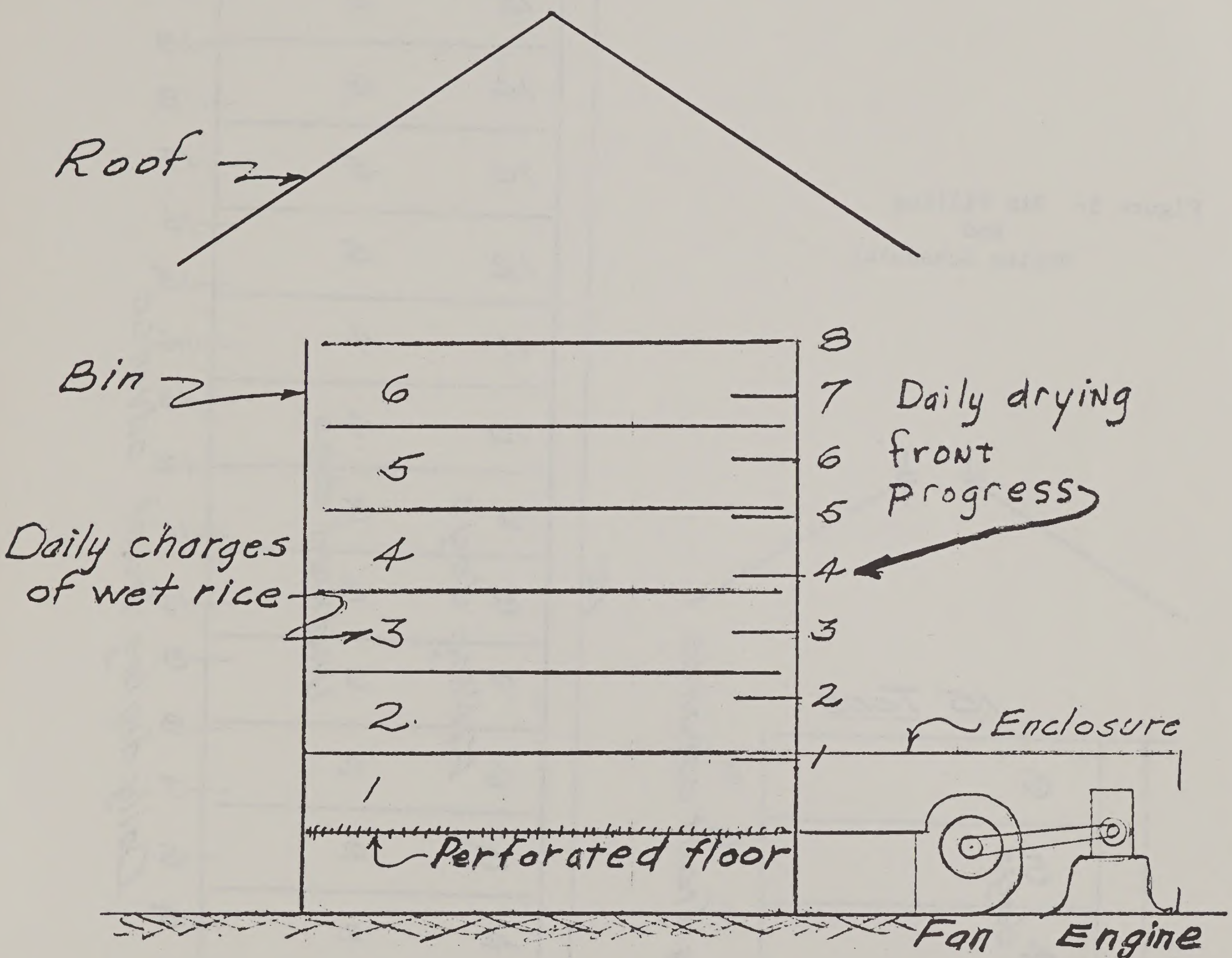

Figure 3- Bin Filling
and
Drying Schedules